

# *Perrottetia wichmaniorum* (Dipentodontaceae), a new species from Kauaʻi, Hawaiian Islands

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## Abstract

*Perrottetia wichmaniorum* Lorence & W. L. Wagner, **sp. nov.** is described as endemic to Kauaʻi. It differs from its Hawaiian congener *P. sandwicensis* by its larger, thicker, more densely hirtellous-villosulous rugose leaves with a smaller length:width ratio [1.5–1.7:1], larger inflorescences with usually four degrees of branching with moderately to densely hirtellous axes, and flowers with glabrous petals. This new species falls into the Endangered (EN) category when evaluated using the IUCN Red List criteria for endangerment based on its small area of occupancy, a decline in the extent and quality of its habitat, and number of mature individuals.

## Keywords

Dipentodontaceae, *Perrottetia*, Hawaiian Islands, Kauaʻi, conservation, IUCN Red List, endangered

## Introduction

*Perrottetia* Kunth is a genus of 16–17 species of shrubs or small trees distributed from China, Malesia, Australia, and the Pacific to Central and South America, with a center of diversity in Colombia (Ding 1962; Lundell 1985; Mabberley 2017; Sánchez Montano and Fernández Alonso 2000). Formerly *Perrottetia* was often included in Celastraceae (e.g., Ding Hou 1962; Matthews and Endress 2005). However, recent molecular evidence places it in Dipentodontaceae in the small order Huerteales (Zhang and Simmons 2006; Worberg et al. 2009). In their treatment of *Perrottetia* in the Hawaiian

Islands, Wagner et al. (1990, 1999) recognized a single species, *P. sandwicensis* A. Gray, occurring on all the main islands except Ni‘ihau and Kaho‘olawe. Subsequent field studies and examination of herbarium specimens from Kaua‘i revealed the presence of a second previously undescribed species. We here describe *Perrottetia wichmaniorum* Lorence & W. L. Wagner, which differs from *P. sandwicensis* by its larger, thicker, more pubescent and rugose leaves with a smaller length:width ratio [1.5–1.7:1], larger inflorescences with up to four degrees of branching and moderately to densely hirtellous axes, and flowers with glabrous petals. This new species is known only from wet forests in the Hanalei District of northern Kaua‘i, where it sometimes grows sympatrically with *P. sandwicensis* and apparently occasionally hybridizes with it. We found the characters separating the two species to be well differentiated in all populations, in addition to their growing sympatrically in some areas. However in both species, smaller plants or branches with smaller leaves may have correspondingly smaller inflorescences that are less highly branched.

The affinities of *Perrottetia* species in the Hawaiian Islands are obscure and would benefit from molecular studies to resolve phylogenetic relationships. Also, the breeding systems of both species should be studied in more detail in the field. The breeding system of *P. sandwicensis* was first described as being polygamodioecious by Gray (1854). That of *P. wichmaniorum* as being dioecious is based on our own observations. The breeding system for both species is characterized based on morphology and not experimental results that should be considered in future work.

### Key to the Hawaiian Species of *Perrottetia*

- 1      Leaves with blade broadly elliptic, broadly ovate, or suborbicular, 7–18.5 cm long, 4.5–10.5 cm wide [length:width 1.5–1.7:1], stiffly chartaceous to subcoriaceous, rugose with venation depressed adaxially and prominulous abaxially; inflorescences with usually four degrees of branching, the axes moderately to densely hirtellous; petals glabrous ..... **1. *Perrottetia wichmaniorum***
- Leaves with blade ovate, elliptic, or oblong-elliptic, rarely obovate or broadly elliptic (Maui), 7–19 cm long, 2.5–9.5 cm wide [length:width 1.8–2.7:1], chartaceous, smooth, the venation not depressed adaxially nor prominulous abaxially; inflorescences with up to three (rarely to four on Kaua‘i) degrees of branching, the axes glabrate to densely brown villosulous; petals with ciliolate margins.....**2. *Perrottetia sandwicensis***

#### **1. *Perrottetia wichmaniorum* Lorence & W. L. Wagner, sp. nov.**

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Figs 1, 2A–C

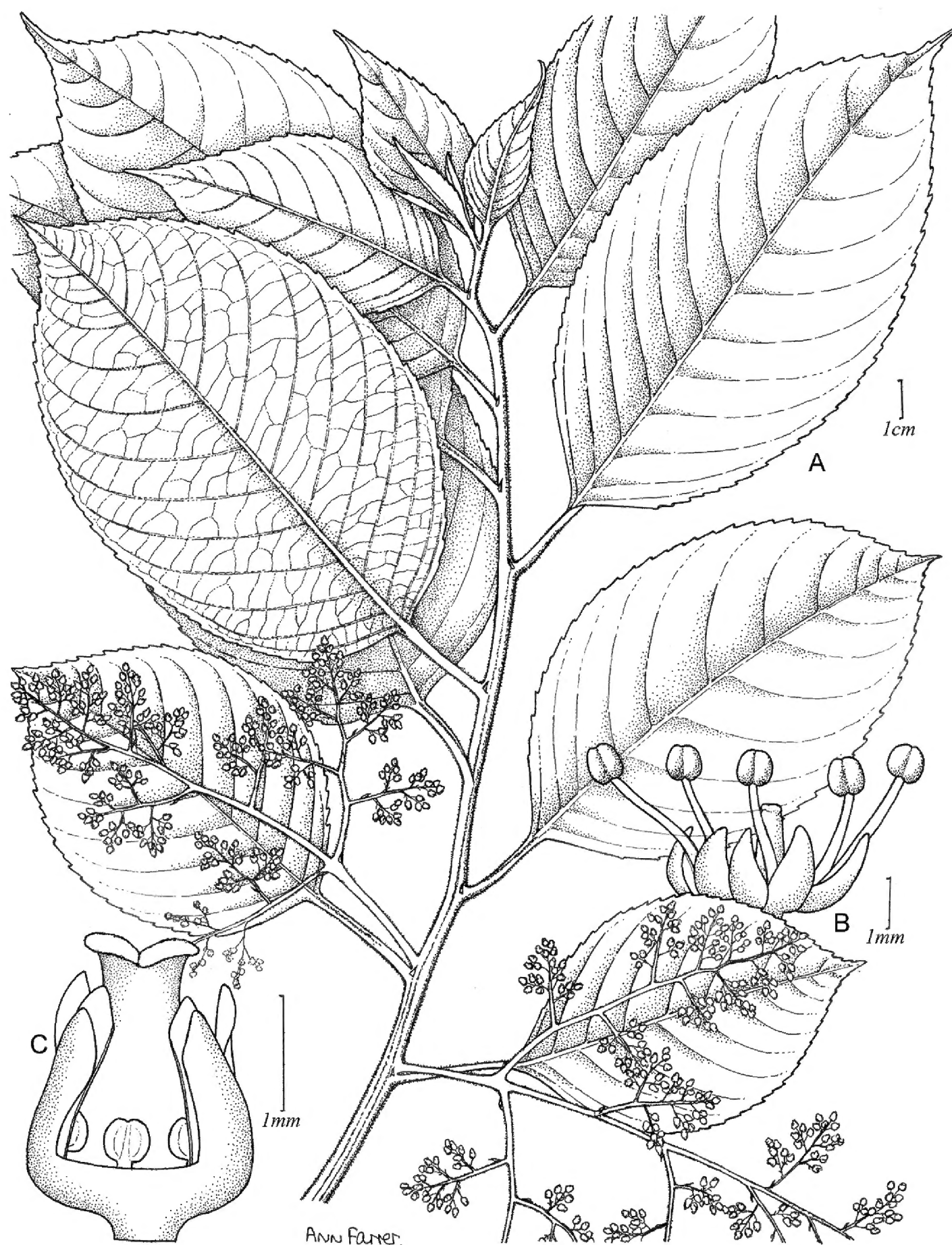
**Diagnosis.** *Perrottetia wichmaniorum* is similar to *P. sandwicensis* from which it differs by its larger, thicker, more pubescent and rugose leaves with a smaller length:width ratio

[1.5–1.7:1], larger inflorescences with usually four degrees of branching with moderately to densely hirtellous axes, the staminate inflorescences 12.5–14 cm long, 10–13 cm wide, the pistillate inflorescences 9–13 cm long, 6–13 cm wide, and flowers of both sexes with glabrous petals.

**Type. Hawaiian Islands: Kaua'i:** Hanalei District, Nā Pali-Kona Forest Reserve; upper Hanakoa Valley north of Pihea Peak, 3900–4000 ft, 21 Dec. 1988 (pistillate), *T. Flynn & D. H. Lorence 3246* (Holotype: PTBG-014949!; Isotypes AD!, F!, MO!, MU!, SING!, US!).

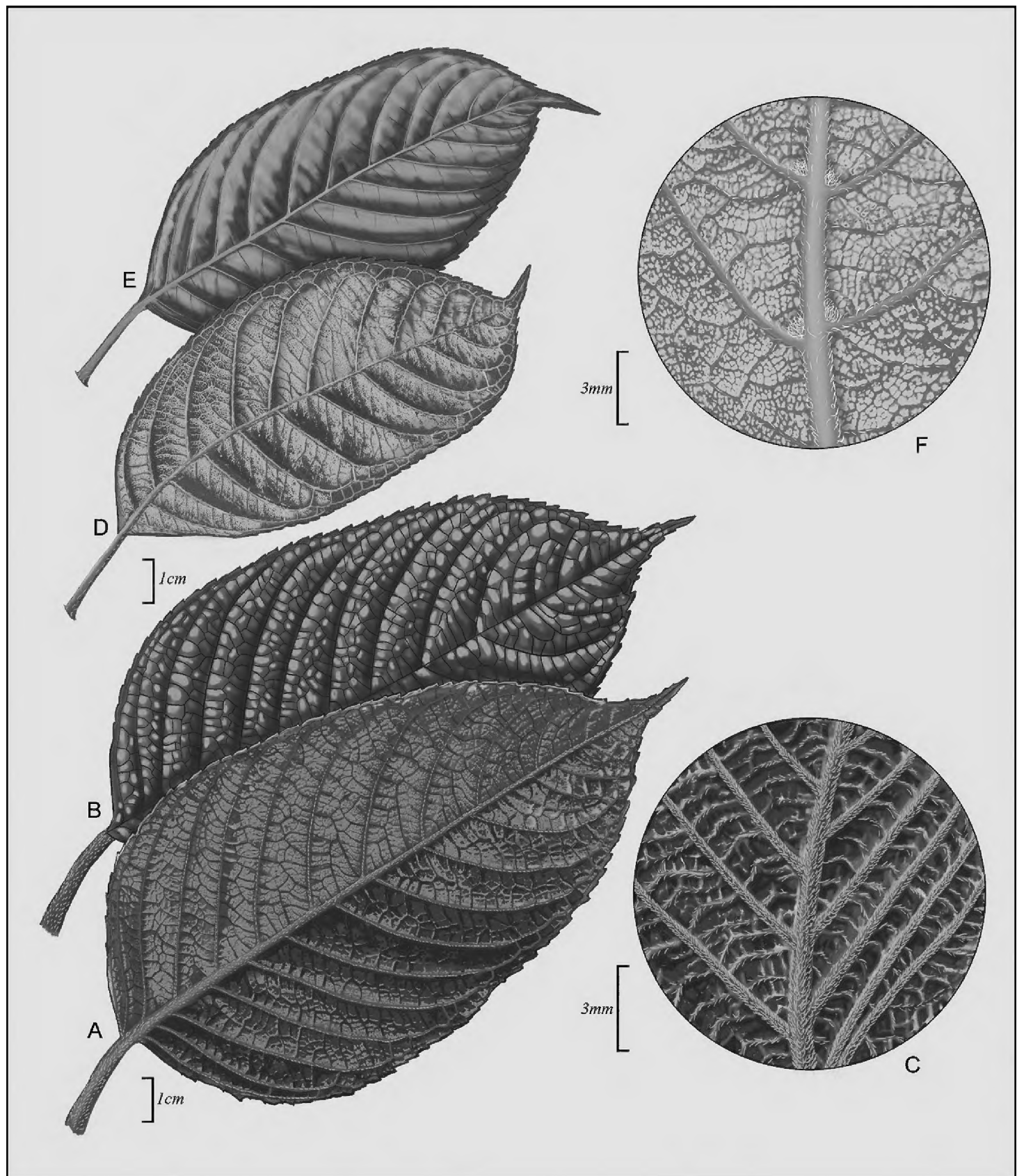
**Description.** Sprawling dioecious small tree 1.5–3 m tall with a dense crown or sometimes a shrub; branches when fresh green or sometimes purple or maroon-tinged, densely villous-hirtellous with pale brown hairs 0.2–0.5 mm long. Leaves spirally arranged, dark green except petioles and veins usually purple or maroon-tinged when fresh; blade thickly chartaceous to subcoriaceous, broadly elliptic, broadly ovate, or suborbicular, 7–18.5 cm long, 4.5–10.5 cm wide [length:width 1.5–1.7:1], adaxially glabrous, rugose with secondary, tertiary, and quaternary venation depressed, abaxially with venation prominulous, densely hirtellous-villosulous along costa and on veins, the hairs rufous, 0.2–0.6 mm long, the secondary veins 9–12 on each side, the axils occasionally with hair tufts, the tertiary veins conspicuously anastomosing, base broadly cuneate to obtuse or truncate, apex acute to rounded, the tip short acuminate, margin serrate-dentate, the teeth 0.5–1 mm long, tips indurated; petiole 1.5–5 cm long, brown villosulous or glabrate; stipules linear-oblong, 2–2.4 mm long, glabrous, deciduous. *Inflorescences* of both sexes axillary or occasionally infraxillary, paniculate cymes with usually four degrees of branching, pyramidal, purple or maroon-tinged, the staminate 12.5–14 cm long, 10–13 cm wide, the pistillate 9–13 cm long, 6–13 cm wide, both with the peduncle 2–4 cm; axes densely rufous hirtellous, the hairs 0.2–0.3 mm long, bracts glabrous, ovate-elliptic or subulate, those on primary branches 1.8–2.0 mm long, those on secondary branches 1.2–1.5 mm long, those on tertiary branches 1–1.2 mm long, pedicels with 1–3 glabrous linear-oblong to subulate bracts 0.5–1.5 mm long; flowers on glabrous pedicels 0.5–1 mm long, hirtellous below articulation with ultimate axis. Staminate flowers with sepals and petals 5, spreading at anthesis, sepals purplish green, ovate, 1.0–1.2 mm long, apex acute to acuminate, glabrous, margins entire, petals white, ovate, similar to sepals in size but thinner, glabrous, margins entire; stamens on filaments 2–2.5 mm long, anthers transverse-ellipsoid, 0.5–0.6 mm long, 0.6–0.7 mm wide; pistillode 0.8–1.0 mm. Pistillate flowers with sepals and petals 5, glabrous, subequal, not spreading at anthesis, sepals reddish purple, ovate-deltate, 1–1.4 mm long, apex acute, petals white, ovate, similar in size to sepals but thinner; pistil conical, 1.2–1.5 mm long, stigma lobes 2(3), papillose; staminodes 5, 0.3–0.4 mm long. *Infructescence* 8–14.5 cm long, 6–14 cm wide. *Fruit* a globose berry 2.5–4 mm in diameter, ripening red or purple tinged, glabrous. *Seeds* (2–)4, subglobose, tan, 1.2–1.5 mm long, with thin aril, the testa rugose-reticulate.

**Distribution.** Hawaiian Islands, northern Kaua'i, known only from the Hanalei District, growing along streams or on windward upper valley slopes and summit areas above the valleys at c. 740–1280 m (Fig 3). Collections are known from the upper Waioli Valley in the east and along the Nā Pali Coast to Awa'awapuhi Valley in the west, although they likely also occur in intervening areas with suitable habitat.



**Figure 1.** *Perrottetia wichmaniorum* Lorence & W. L. Wagner **A** Habit, branch with pistillate inflorescences **B** Staminate flower **C** Pistillate flower. **A**, **C** drawn from holotype *T. Flynn* & *D. H. Lorence* 3246 (PTBG), **B** from *T. Flynn* & *L. Hume* 3292 (PTBG).





**Figure 2.** *Perrottetia wichmaniorum* (A–C) **A** Abaxial leaf surface **B** Adaxial leaf surface **C** inset of abaxial leaf surface. Drawn from isotype and field images of *T. Flynn* & *D. H. Lorence* 3246 (US), and *W. L. Wagner et al.* 6265 (US). *Perrottetia sandwicensis* A. Gray (D–F) **D** Abaxial leaf surface **E** Adaxial leaf surface **F** inset of abaxial leaf surface. Drawn from *D. Herbst* 871 (US). Field images from Forrest and Kim Starr [<http://www.starrenvironmental.com/resources/>] were used to augment illustration, especially colors: Ko‘olau Gap, Maui [#110713-7251 (25006081321\_ac9bdd7fdb\_o), #110713-7252 (24731716429\_d7c44c451a\_o), and #110713-7253 (25006085211\_f687c67af8\_o)]; Road to Lower Kula Pipeline Haiku Uka, Maui [#170520-0692 (34385766464\_bb0d9bc7d0\_o), #170520-0693 (34385767704\_f28a1b34d7\_o)].

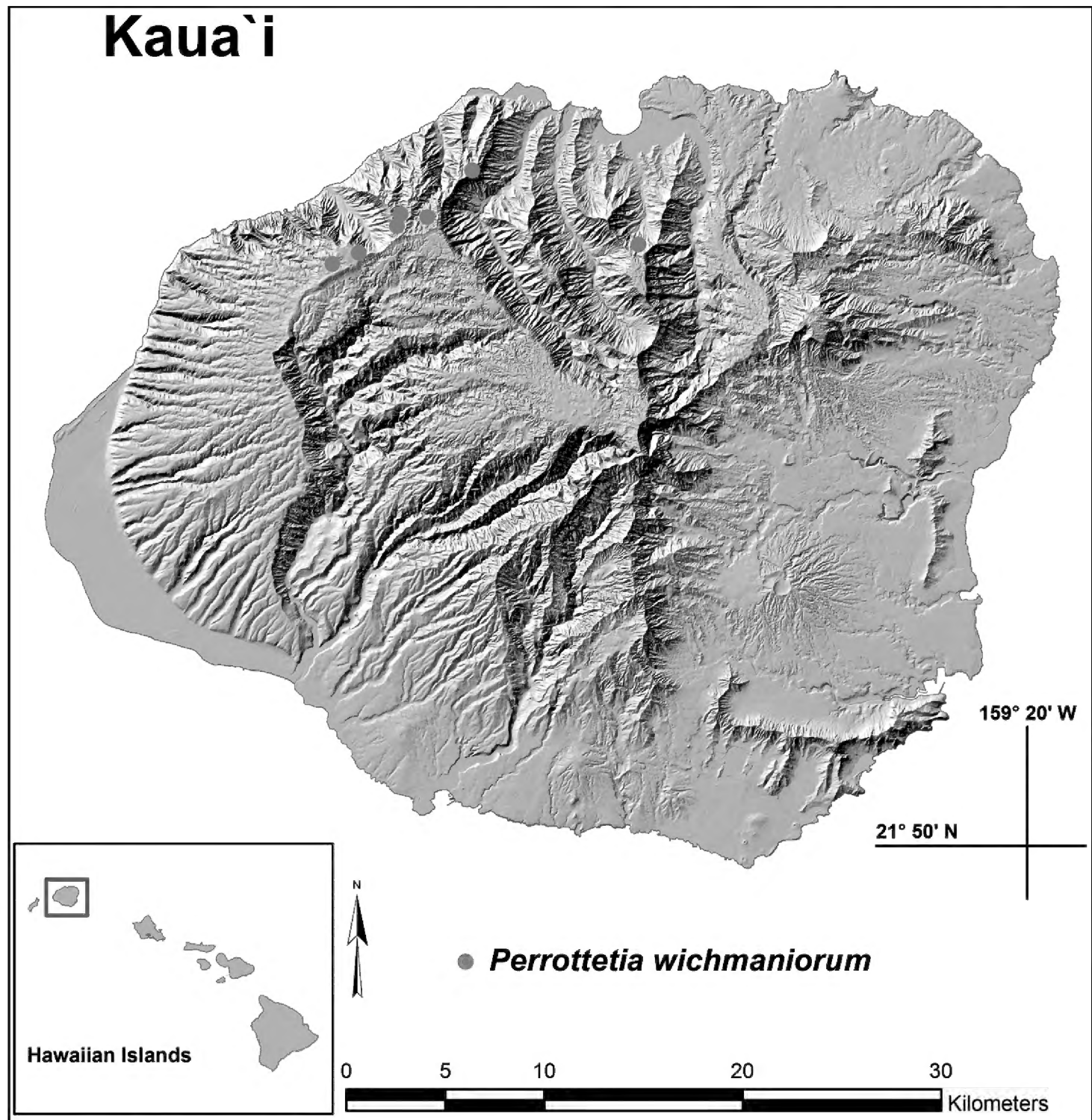
**Habitat and ecology.** This new species grows in diverse wet forest with species of *Metrosideros* Banks ex Gaertn. dominant, associated with species of *Cheirodendron* Nutt. ex Seemann, *Syzygium* Gaertn., *Psychotria* L., *Melicope* J. R. Forst. & G. Forst., *Broussaisia* Gaud., *Dubautia* Gaud., *Smilax* Tourn. ex L., *Astelia* Banks & Sol. ex R. Br., and diverse ferns including *Dicranopteris linearis* (Burm. f.) Underw., *Cibotium* Kaulf., *Sadleria* Kaulf., and *Diplazium* Sw. Flowering was observed from November to June and fruiting from January to August.

**Threats.** Threats to this species include invasive alien plant species, primarily *Axonopus fissifolius* (Raddi) Kuhl., *Buddleja asiatica* Lour., *Clidemia hirta* (L.) D. Don var. *hirta*, *Erigeron karvinskianus* DC., *Hedychium gardnerianum* Sheppard ex Ker Gawl., *Juncus planifolius* R. Br., *Rubus argutus* Link, and *R. rosifolius* Sm. Habitat modification by introduced pigs (*Sus scrofa*), blacktail deer (*Odocoileus hemionus*), and goats (*Capra hircus*) also negatively impact this species. Although recorded as first naturalized on Kauaʻi as recently as 2004, *Buddleja asiatica* is rapidly becoming a very serious invasive species in the same wet drainages and riparian zones in which *Perrottetia wichmaniorum* occurs.

**Conservation status.** When evaluated using the World Conservation Union's IUCN Red List criteria for endangerment (IUCN 2012), *Perrottetia wichmaniorum* falls into the Endangered (EN) category, a designation recommended for taxa facing a very high risk of extinction in the wild. The species merits this designation by having a very small Extent of Occurrence (EOO) of ca. 35 km<sup>2</sup>, along with a small Area of Occupancy (AOO) of ca. 10 km<sup>2</sup>, and an estimated population of ca. 7200 individuals (K. R. Wood, pers. comm.). The formal IUCN coding system for our evaluation is EN, B1ab(i,ii,iii,v)+2ab(i,ii,iii,v), which indicates that *P. wichmaniorum* is subject to an inferred decline in its area of occupancy, in addition to a decline in the extent and quality of its habitat and number of mature individuals.

**Etymology.** We take pleasure in naming this new species for Charles R. “Chipper” Wichman, Jr., who has served as Director and CEO of the National Tropical Botanical Garden (NTBG) since 2005, and his wife Hauʻoli Wichman, who has served alongside Chipper throughout his directorship, for both their service on behalf of the Garden and especially for their efforts to conserve the Hawaiian Flora. Chipper has also served as Director of NTBG's Kahanu Garden on Maui and Limahuli Garden on Kauaʻi, where the new species occurs in the Upper Limahuli Preserve.

**Specimens examined (paratypes). Hawaiian Islands.** Kauaʻi: Hanalei District. Nā Pali-Kona Forest Reserve, upper Hanakoa Valley north of Pihea peak, *T. Flynn et al.* 2937 (AD, F, PTBG), *T. Flynn & D. H. Lorence* 3247 (BISH, PTBG, US); Kōkeʻe State Park, Hwy 550 at mile 19 [southern rim of Kalalau Valley], along north side of road, *T. Flynn et al.* 3257 (PTBG); Kōkeʻe State Park, Awaʻawapuhi Valley west and below Hwy 550, *T. Flynn & D. H. Lorence* 3260 (PTBG); Kōkeʻe State Park, along Hwy 550 near mile 19 on edge of Kalalau Valley, *T. Flynn & L. Hume* 3292 (PTBG); upper Hanakoa Valley just E of Kalalau Valley rim, *D. H. Lorence et al.* 6312 (BISH, PTBG, US); upper Waioli Stream Valley, main waterfall, hanging valley between upper and lower falls on N face of Nāmolo-kama Mt., *D. H. Lorence et al.* 7295 (PTBG); Kalalau rim, north, below



**Figure 3.** Distribution map showing known locations of *Perrottetia wichmaniorum* on Kauaʻi.

Puʻu o Kila, *K. R. Wood* 1047 (PTBG); Kalalau rim, NW facing aspect, below Pihea Peak, *K. R. Wood* 1132 (BISH, PTBG, US); upper Hanakoa valley from Pihea peak, southwest facing cliffs, *K. R. Wood et al.* 2218 (PTBG); upper Hanakāpīʻai drainage and the North Bog area along Wainiha Rim (ridge to Hono o nā pali), below in Hanakāpīʻai head-water, east drainage, *K. R. Wood* 5272 (PTBG); upper Hanakoa drainage north of Pihea peak, west of Moaʻalele, *K. R. Wood & S. Perlman* 7453-A (PTBG, US); Limahuli, upper south-east corner below Pali Eleʻele, *K. R. Wood* 7508 (PTBG); below Pihea Peak in Upper Hanakoa Valley, *W. L. Wagner et al.* 6265 (PTBG, US).

**Discussion.** This new species sometimes grows sympatrically with *P. sandwicensis* with which it occasionally hybridizes. Two examples of putative hybrids were recognizable by their intermediate leaf morphology and inflorescence structure, if fertile.



**Putative hybrids. Hawaiian Islands.** Kaua‘i: Hanalei District. Kōke‘e State Park, mile 19 of Highway 550 just below Pu‘u o Kila lookout on southern rim of Kalalau Valley, *D. H. Lorence et al.* 6001 (BISH, MO, NY, PTBG, US), Highway 550, mile 19 [southern rim of Kalalau Valley], *T. Flynn et al.* 3256 (PTBG).

## 2. *Perrottetia sandwicensis* A. Gray, U. S. Expl. Exped., Phan. 291. 1854.

Fig 2D–F

**Type.** Hawaiian Islands: O‘ahu. On mts. behind Honolulu. 1840. *U. S. Expl. Exped. s.n.* (Lectotype: US-16429!; Isolectotype: GH [GH-00050026!]), designated by St. John, *Rhodora* 87: 570. 1985.

**Note.** Gray also cited a Gaudichaud collection from the same locality, as well as “also Hawai‘i; along the margin of forests.” The US sheet does not have a specific locality.

*Perrottetia sandwicensis* A. Gray var. *tomentosa* O. Deg. & Greenwell, Rev. S. Am. Bot. 10(1): 25 1951.

**Type.** Hawaiian Islands: Maui. Mauka of Nawini, S slope of Haleakalā, in gulch in decadent forest, 24 November 1950, *O. Degener*, *A. B. Greenwell*, *W. H. Hatheway*, *Miller*, *Silva* 21119 (Holotype: NY [NY-00337484!]; Isotype: BISH-501715!).

**Description.** Polygamodioecious shrub or small slender tree 2–6(–8) m tall; branches when fresh red to green, usually glabrous or glabrate, sometimes strigulose or villous-tomentose with light brown hairs 0.1–0.4 mm long. Leaves spirally arranged, shiny, dark green except veins and petioles usually pink, red, or reddish orange; blade chartaceous, ovate, elliptic, or oblong-elliptic, rarely obovate or broadly elliptic (Maui), 7–19 cm long, 2.5–9.5 cm wide [length:width 1.8–2.7:1], adaxially relatively smooth, glabrous, abaxially somewhat paler and glabrate to moderately villosulous (Maui), especially along veins and on young leaves, the hairs yellowish brown, 0.4–0.8 mm long, the secondary veins 8–11 on each side, usually with hair tufts in secondary and tertiary vein axils, the tertiary and quaternary veins usually not prominulous below, apex long- to short-acuminate or sometimes rounded or obtuse (Maui), base cuneate to obtuse or rounded, margin serrate, the teeth 0.3–1 mm long, tips indurated; petiole 1.5–5 cm long, sparsely to moderately pale brown villosulous-hirsute or glabrate; stipules linear-oblong, 1–1.5 mm long, glabrous or puberulent, deciduous. Inflorescences of both sexes axillary or occasionally infraxillary, paniculate cymes, pyramidal, with two to three (rarely to four on Kaua‘i) degrees of branching, the peduncle (0.5–) 1–4 cm, the staminate 4–7(–12) cm long, 2–6 cm wide, the pistillate 3–5 cm long, 2–3 cm wide; axes glabrate to densely brown villosulous, the hairs 0.1–0.4 mm long, bracts glabrous, triangular-subulate, those on primary branches 0.4–1.0 mm long, those on secondary branches 0.5–1.0 mm long, pedicels with 1–3 bracts 0.5–0.8 mm long; flowers on glabrous or puberulent, articulate pedicels 1–3.5 mm long. Staminate flowers with sepals and petals 5, calyx greenish orange, sometimes red-margined, sepals deltate, 0.5–0.7 mm long, margins entire, petals similar in color and shape to sepals but thinner, 0.6–0.8 mm long, 1–1.2 mm wide, margins ciliate; stamens with filaments 1.5–1.9 mm long,



anthers transverse ellipsoid, 0.5–0.6 mm long, 0.6–0.7 mm wide; pistillode 0.5–0.7 mm. Pistillate flowers with sepals and petals 5, bracteolate, with calyx greenish orange to red, sepals deltate, 0.6–1.5 mm long, 0.5–0.7 mm wide, petals similar in color and shape but thinner, deltate, 0.6–1.1 mm long, margins ciliate; pistil ovoid, 1.0–1.5 mm long, stigma lobes 2, papillose; staminodes 5, 0.3–0.4 mm long. *Infructescence* 5–10 cm long, 3.5–7 cm wide. *Fruit* a depressed-globose berry (2–)4–6 mm in diameter, reddish-green, ripening bright red, or white and red-tinged, glabrous. *Seeds* (2–)4, triangular-globose, 1.3–1.5 mm long, with thin aril, the testa rugose-reticulate, or sometimes only with transverse wavy lines.

**Distribution.** Hawaiian Islands, endemic to Kaua'i, O'ahu, Moloka'i, Lana'i, Maui, and Hawai'i. In mesic and wet forests, c. 300–1250 (–1830 on Maui) m elevation. Flowering was observed from November through July and fruiting from November through August.

**Common names.** Olomea, Pua'a olomea, Waimea (Maui).

**Discussion.** Some collections from East Maui have loosely villosulous stems and lower leaf surface with curling hairs, including the type of *Perrottetia sandwicensis* var. *tomentosa*, but these otherwise correspond to typical *P. sandwicensis*. Since the degree of pubescence intergrades with typical sparsely puberulent or glabrate forms, this variety was not recognized by Wagner et al. 1990, 1999. Pubescence in *P. wichmaniorum* is usually spreading hirtellous with straight hairs and is especially dense on the inflorescence axes and young stems and leaves.

**Representative specimens examined. Hawaiian Islands:** Kaua'i. Hanalei District, Kōke'e State Park. Hwy 550 at mile 19, along north side of road, *T. Flynn et al.* 3255 (PTBG); Nā Pali-Kona Forest Reserve, upper Hanakoa Valley north of Pihea peak, *T. Flynn & D. H. Lorence* 3244 (PTBG, US); Koloa District, Kahili Ridge, *W. L. Stern et al.* 3114 (NY, US); Waimea District: Mohihi Valley, *E. H. Bryan* 1451 (BISH, US); Kaunuohua Ridge between Kilohana Lookout at Pu'u o Kila and Pihea, *W. L. Stern & S. Carlquist* 1242 (US); Makaha, north facing slopes below and west of Kokio keokeo, *K. R. Wood & M. Query* 15806 (PTBG, US). **O'ahu.** Kona District, Wa'ahila Ridge, on Ko'olau summit ridge past Mount Olympus summit, *J. W. Adams & M. Bond* 95 (PTBG); ridge E. Nu'uanu Valley, *C. N. Forbes* 1434 (BISH, US); Ko'olauloa District, Punalu'u, Castle trail, *B. C. Stone* 1158 (US), Waikane-Schofield trail, Waikane side, *T. G. Yuncker* 3197 (US); 'Ewa District, Kipapa Gulch, S ridge, *E. Y. Hosaka* 711 (BISH, US); Wai'anae District, Mt. Ka'ala, near road, *O. Degener & I. Degener* 28015 (US), below summit ridge of head of Makua Valley, *O. Degener & W. Hatheway* 21166 (BISH, US); Pu'u Kalena, *W. R. Donaghho s.n.* (US). **Lana'i.** Munro Trail, ca. ½ mile from fog drip station, in bottom of feeder valley to Maunalei Gulch, *T. Flynn & D. Palumbo* 255 (PTBG); Pu'u Kole, 14 Jan 1964, *O. Degener & I. Degener* 30159 (BISH, US), Ha'aleiepa'akai, Kaohai, *H. St. John & A. J. Eames* 18788 (BISH, US). **Moloka'i.** upper end of Hanalilolilo pipe-line, *O. Degener* 8971 (BISH, US); west ridge of Honomuni, *H. St. John* 25194 (BISH, US). **Maui.** W. Maui; Wailuku District, Kahakuloa Drainage, *K. R. Wood* 3144 (AD, NY, PTBG); near last ditchman's house on way to Mt. Eke, *O. Degener & H. Wiebke* 2561 (US); Lahina District, Honokahau Drainage

Basin, *C. N. Forbes* 496.M (US); ravine back of Lahaina, *A. S. Hitchcock* 14882 (US); E. Maui, Makawao District, Ahupuaʻa of Kalialinui, upper Koʻolau Gap, 1.5 mi east of Hosmer's Grove, *P. K. Higashino* 780 (BISH, US); Haleakala, Koʻolau Gap, valley on west side, 2 mi N of Holua Cave, *H. St. John & A. L. Mitchell* 21281 (BISH, US), Hana District, Kaeanae Gap, crater of Haleakalā, *C. N. Forbes* 1071.M (US). **Hawaiʻi.** N. Hilo District, Laupāhoehoe Natural Area Reserve, follow Kilauea Stream, *K. R. Wood et al.* 3184 (MO, NY, PTBG, WU); S. Hilo District, ʻŌlaʻa State Forest Preserve, 14 Aug 1975, *S. P. Darwin* 1218 (PTBG, US); N side of Stainback Hwy. 10 mi. above junction with Hwy. 11, 31 Jan 1968, *D. Herbst* 871 (BISH, US); Kaʻū District, Route 148a, NE of Kilauea, 11 Jul 1961, *O. Degener & I. Degener* 28197 (BISH, US).

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We are grateful to Tim Flynn for first bringing our attention to this new species and for his careful review of the manuscript, to Ken Wood for his constructive comments on the manuscript including conservation status and for creating the distribution map (Figure 3), and to Ben Nyberg for his help with the map and calculating the EOO and AOO. Ann Farrar, formerly of RBG Kew, drew the illustration (Figure 1), and Alice Tangerini drew insets of the pubescence types and prepared the leaf comparison plate (Figure 2). We thank Forest and Kim Starr for the use of images of *Perrottetia sandwicensis* from their website (<http://www.starrenvironmental.com>) used in the preparation of Figure 2D–F. We thank the State of Hawaii Division of Land and Natural Resources (DLNR), Kauaʻi District Office, and Kauaʻi Division of State Parks for permission to collect plant specimens and conduct fieldwork. We are grateful to curators of the following herbaria for making specimens available for study: BISH, NY, PTBG, US. We extend our thanks to Barbara Kennedy for providing digital images of specimens at BISH.

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